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CONFERENCE ON THE ELECTRICAL MODELING OF PHYSICAL PHENOMENA

N. V. Korol'kov
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A conference on the electrical modeling of physical phenomena was held in July 1949 at the Institute of Precision Mechanics and Computer Technology, (ITM i VT) of the Academy of Sciences USSR.

Representatives of 45 organizations in Moscow, Leningrad, Kiev, Kuybyshev, Dnepropetrovsk, Penza, and other cities of the USSR took part in the conference.

Thirty-two reports were read, mainly on the results of work on the theory and practice of applying for the electrical modeling of physical phenomena in various branches of science and engineering.

Academician N. G. Bruyevich opened the conference. He stressed the necessity for the creation of new electrical models and for the improvement of existing calculating and solving mechanisms and machines to meet the urgent demands of present-day science and engineering. Bruyevich noted the following:

Soviet scientists have done much to develop computer technology. More than 20 years ago, Professor S. A. Gershgorin, who had done much work on designing mathematical machines, proposed a special electrical resistance grid to solve Laplace's equation. The creation of electrical-mathematical machines and models is continuing successfully in our country.

The purpose of the first conference on electrical modeling is to discuss the results of work in this new field of science created by Soviet scientists.

Professor L. I. Gutenmakher, Doctor of Technical Sciences, read a long paper on the present and future of electrical modeling. He noted the rapid development of this new field of technology in the Soviet Union, as follows:

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Mathematics generalizes basic physical relationships but is not very efficient in solving the equations. Engineering has now advanced so far that it has created the necessary means for a revolution in the field of experimental mathematics, or machine mathematics. Machine mathematics makes it possible to solve the equations and, as a result, one may expect a brilliant new development of natural sciences.

The theory and practice of the electrical modeling of the main equations of mathematical physics were developed 10 years ago in the Academy of Sciences USSR. Electrical dynamic models for solving systems of ordinary differential equations were first made in the USSR by using electronic tubes.

The Party and the government are promoting the development of electrical modeling. The state of theory and practice in electrical modeling is such that all the basic prerequisites for its successful development are present.

The chief tasks are now:

1. To train skilled personnel for electrical modeling of physical phenomena.

2. To establish modeling laboratories and stations in large organizations.

3. To start instructing various personnel and popularize the method among engineers and scientific workers.

4. To perfect and automatize the models and installations, mass-produce the elements, blocks, and components, and reduce the cost of modeling equipment.

The speaker remarked that in spite of the obvious priority of the Soviet Union in the invention and development of electric and electronic tube models and integrators, American firms are obstinately striving to claim the credit for these important inventions. In November 1945, Academician G. M. Krzhizhanovskiy had to publish an open letter on this subject in the journal Proceedings Radioengineere [sic]. Soviet papers on electronic tube models were published as early as the beginning of 1945, while in the US the first articles on the problem were not published until May 1947. The theoretical level of the work of the American authors is considerably below that of the Soviet.

L. G. Kogan, Candidate in Technical Sciences ITM i VT, compared the technical-economic effectiveness of electrointegrators and the most modern analytical-computer machines (tabulators, perforators, etc.) for solving differential equations (ordinary and partial derivatives). He showed, by numerous examples, that the problems can be solved more quickly and economically on the integrators than on the analytical computer machines.

The report of I. S. Gradshteyn, Candidate in Physicomathematical Sciences, Moscow State University, was devoted to the performance accuracy of electrical models. He spoke on the results of investigating the influence of small parameters on the solution of differential equations using electrical models with amplifiers.

D. A. Efros Candidate in Technical Sciences. All-Union Scientific Research Institute, Ministry of Petroleum Industry, (VNII, MNP) described the modeling of discontinuous currents of an incompressible liquid. He has worked out a new method for investigating the phenomena of cavitation by means of which it is possible to obtain the solution of a problem of this type on an electrointegrator.

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Engineer A. D. Smirnov, Scientific Research Institute (NII) investigated the movement of liquid in radial settling tanks with the help of Type EI-11 and EI-12 electrointegrators.

N. I. Shteyn, Candidate in Technical Sciences, Moscow Power Engineering Institute read a report on methods for the electrical modeling of wave guides. He showed that an investigation can be carried out very simply by means of an electrical model.

S. F. Novakovskiy, Candidate in Technical Sciences, Dnepropetrovsk, used an electrointegrator for investigating the heat processes in pressure pipe lines installed in frozen ground. The results of his investigations are of great practical importance, as they permit the depth at which the pipe is laid to be reduced.

L. G. Kogan, Candidate in Technical Sciences, ITM i VT, described the modeling of an automatic voltage regulation system. He used a special, nonlinear converter which he designed in accordance with an idea of Professor L. I. Gutenmakher.

N. P. Kunitskiy, Candidate in Technical Sciences, Electric Welding Section, Academy of Science USSR, read a paper on modeling the control system of a rolling mill with a machine amplifier. Investigations carried out by the speaker using an electrointegrator, disclosed the effect of individual parameters of the control system of a rolling mill.

N. V. Korol'kov, Candidate in Technical Sciences, ITM i VT described his method of investigating eddy currents arising during the movement of a conducting medium in a constant magnetic field.

Engineer A. A. Vishnevskiy (NII) read a report on "Selection of the Parameters of a Nonlinear Servomechanism."

N. G. Gorchakov, Candidate in Technical Sciences, Electrical Engineering Institute, Academy of Sciences Ukrainian SSR, investigated nonlinear torsional oscillations of a shaft with elastic coupling, using an electrical model of R-L-C elements with semiconductor tubes which he had constructed.

N. Ya. Al'per, Candidate in Technical Sciences, NII, Ministry of Electrical Industry, modeled the field in the air gap of induction machines for various distribution conditions of the magnetic potential over the iron surface. As a result of these investigations, it was possible to obtain a whole series of important coefficients necessary in the practical design of induction generators.

S. S. Vyalov, Candidate in Technical Sciences, Institute of Frost Studies, Academy of Science USSR, read a report on the electromodeling of certain heat processes in soils with the aid of electrointegrators. As a result of the investigation, conclusions were drawn concerning the rational construction of foundations and heat insulation.

S. N. Shan gin, Doctor of Geological - Mineralogical Sciences, VNII MNP, described the use of the electrical modeling method in the geological analysis of oil-field development. Electrical modeling permits the most advantageous layout of wells in an oil field to be determined, and is of considerable assistance in the calculation of conditions for maintaining pressure when pumping water or gas into the strata. and so on. The speaker remarked that it is necessary to extend considerably the method of electrical modeling by introducing it into oil-field practice to solve the everyday tasks confronting engineers on the job.

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Engineers G. K. Kuz'minok and I. V. Vipper, ITM i VT, read reports on their experiences in using electrointegrators to solve linear differential equations with constant coefficients. Kuz'minok described the construction and operation of the first working model of the type ELI-11 electrointegrator. The design can be used by organizations wishing to construct a simplified electrointegrator using their own resources. Vipper compared Type ELI-10, ELI-11, and ELI-13 integrators. He determined the error of the ELI-13 instrument by solving a number of test problems.

Engineer I. A. Vissonova, ITM i VT, read a report on the procedure for testing separate components and units of Type ELI electronic tube integrators.

Many speakers reported on the construction and design of the new integrators.

Professor V. Ye. D'yachenko, Corresponding Member, Academy of Sciences Ukrainian SSR, spoke of the work of Kiev State University in the field of electrical modeling. He announced that an electrical modeling laboratory, based on the work of Professor L. I. Gutenmakher, was organized at Kiev State University in 1945-47. Electric integrators of the grid type with constant resistances were built to solve problems of potential (plane and with axial symmetry) and also with variable resistances. An improved electrointegrator of the grid type, with 1,200 junction points and an automatic measuring device, was designed at Kiev State University in 1948-49 and is almost completed.

Another report on the design of the Kiev State University electrointegrator was read by Engineer Tantsyura. He described interesting design features which increase the flexibility and reliability of the machine.

The report of V. P. Lebedev, Candidate in Technical Sciences, and B. A. Volynskiy, Candidate in Technical Sciences, was devoted to the work of the Institute of Automatics, All-Union Council of Scientific Engineering and Technical Societies (VSNITO) on the construction of electrical models. This institute has produced new types of electrointegrators -- EI-12, EM-1 and EM-2, GPN-1, EI-21 and EM-4 "lambda" -- intended for the solution of special problems.

Engineer Ye. M. Borisov, Institute of Automatics, VSNITO, read a report on the construction and operation of the Type EI-22 electrointegrator.

Professor B. M. Mordovin read a report on the work of the Ministry of Machine and Instrument Building Industry in producing electrical models.

Engineer N. S. Nikolayev spoke on behalf of the "SAM" Penza plant. He explained the difficulties which had been encountered in manufacturing electronic tube integrators and the successes achieved by the plant.

In his report "Experience and Trend of Electrointegrator Design," Engineer N. P. Belyakov, ITM i VT, examined existing types of electrointegrators and the peculiarities of their construction.

L. A. Lyusternik, ITM i VT told of an interesting method of using electrical models. He has worked out a method of determining eigenvalues and eigenfunctions by means of electrical models constructed of resistances and capacitances. Determining the eigenvalues and eigenfunctions is one of the most important tasks encountered in various problems of physics and engineering (quantum physics, theory of oscillations, strength of materials, etc.).

In his report on the same subject, Engineer K. K. Reydik, Institute of Automatics, VSNITO, described the construction of an apparatus for determining eigenvalues and eigenfunctions.

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Engineer A. G. Gesse, Institute of Automatics, VSNITO, read a report on the work of the institute in building three-dimensional electrointegrator models. He gave a detailed analysis of the peculiarities of the three-dimensional models and drew important conclusions regarding their possible designs.

Engineer M. M. Dubinin, VNII MNP, gave an account of an experiment using an "electric magnifier" to solve problems of subterranean hydraulics.

P. F. Fil'chakov, Candidate in Technical Sciences, Kiev Institute of Mathematics, Academy of Sciences Ukrainian SSR, gave an account of an electrical model which he designed to solve problems described by Laplace's equation.

As a result of the conference, a resolution was passed noting that electrical modeling methods, providing a rapid and sufficiently accurate solution of complicated problems in various fields of science and engineering, are becoming a powerful tool in the hands of Soviet scientists and engineers. The theory and practice of electrical modeling, conceived in the USSR, was far in advance of work in this field abroad (USA, England) which was begun at a later date.

The conference showed that many organizations have developed original designs of electrointegrators and electrical models on which important practical problems have already been solved. Insufficient popularization and the introduction of this powerful method into the practice of scientific, instructional, and planning and design organizations were mentioned and also the absence of an adequate number of trained electrical modeling specialists. It was decided to arrange for the production of scientific and popular literature on the theory and practice of electrical modeling, and to hold periodical all-Union conferences on machine mathematics. It was further decided to request the Ministry of Higher Education to train scientific and technical personnel by introducing special courses and practical classes on the theory and practice of electrical modeling in higher educational institutions.

To satisfy the increasing demand for electrical integrators and models, the Ministry of Machine and Instrument Building should design and produce a series of universal electrointegrators, and also provide for the production of standard parts and units for the assembly of electrical models by other organizations. The communications equipment industry was given the task of manufacturing stable and accurate parts and elements necessary for modern integrators.

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